US009422788B2

(12) **United States Patent**
Nguyen et al.

(10) **Patent No.: US 9,422,788 B2**
(45) **Date of Patent: Aug. 23, 2016**

(54) **STRAIGHT-BORE BACK PRESSURE VALVE**

(71) Applicant: **Cameron International Corporation**, Houston, TX (US)

(72) Inventors: **Dennis P. Nguyen**, Pearland, TX (US); **Maria R. Contreras**, Houston, TX (US)

(73) Assignee: **Cameron International Corporation**, Houston, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 194 days.

(21) Appl. No.: **14/144,478**

(22) Filed: **Dec. 30, 2013**

(65) **Prior Publication Data**

US 2014/0182863 A1 Jul. 3, 2014

Related U.S. Application Data

(63) Continuation of application No. 12/920,826, filed as application No. PCT/US2009/037731 on Mar. 19, 2009, now Pat. No. 8,636,058.

(60) Provisional application No. 61/043,580, filed on Apr. 9, 2008.

(51) **Int. Cl.**

E21B 34/02	(2006.01)
E21B 23/01	(2006.01)
E21B 23/04	(2006.01)
E21B 23/06	(2006.01)
E21B 33/12	(2006.01)

(Continued)

(52) **U.S. Cl.**

CPC ***E21B 34/02*** (2013.01); ***E21B 23/01*** (2013.01); ***E21B 23/04*** (2013.01); ***E21B 23/06*** (2013.01); ***E21B 33/129*** (2013.01); ***E21B 33/1285*** (2013.01); *Y10T 137/7837* (2015.04); *Y10T 137/7904* (2015.04)

(58) **Field of Classification Search**

CPC .. E21B 34/02; E21B 33/129; E21B 33/1285; E21B 33/03; E21B 23/01; E21B 23/04; E21B 23/06

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,032,492 A		3/1936	Nathan	
2,139,983 A	*	12/1938	Stone	166/120
2,189,697 A	*	2/1940	Baker	166/119

(Continued)

FOREIGN PATENT DOCUMENTS

CA	2395723 A1 *	2/2003	E21B 33/134
EP	1555386	7/2005	

(Continued)

OTHER PUBLICATIONS

Great Britain Examination Report for GB Application No. GB1016480.4 dated Jan. 31, 2012.

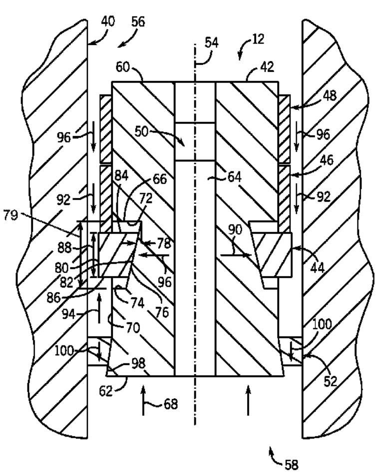
(Continued)

Primary Examiner — Jennifer H Gay
(74) *Attorney, Agent, or Firm* — Fletcher Yoder P.C.

(57) **ABSTRACT**

A system includes a back pressure valve. The back pressure valve includes a body, a plunger disposed internal to the body, and a friction member disposed about the exterior of the body. The friction member is configured to expand radially to contact an internal surface of a bore. A method includes disposing a back pressure valve into a straight bore and expanding a friction member of the back pressure valve radially into contact with an internal surface of the straight bore.

31 Claims, 6 Drawing Sheets



(51) **Int. Cl.**
E21B 33/128 (2006.01)
E21B 33/129 (2006.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

RE22,180	E	*	9/1942	Otis	166/133
2,331,532	A		10/1943	Bassinger	
2,350,973	A	*	6/1944	Brumleu et al.	166/106
2,355,199	A	*	8/1944	Bassinger	166/128
2,589,506	A	*	3/1952	Morrisett	166/123
2,842,212	A	*	7/1958	Lebourg	166/125
2,958,336	A	*	11/1960	Yancey	137/879
3,062,291	A	*	11/1962	Brown	166/119
3,152,643	A		10/1964	Burns	
3,250,331	A	*	5/1966	Boyle	166/133
3,291,220	A	*	12/1966	Mott	166/208
3,332,494	A	*	7/1967	Scott	166/121
3,387,659	A	*	6/1968	Current	166/125
3,434,538	A	*	3/1969	Pumpelly et al.	166/123
3,461,959	A	*	8/1969	Conrad	166/123
3,467,183	A	*	9/1969	Young	166/121
3,468,375	A	*	9/1969	States	166/120
3,789,925	A	*	2/1974	Brown	166/125
4,058,162	A	*	11/1977	Smith	166/124
4,237,979	A	*	12/1980	Weise	166/373
4,395,809	A		8/1983	Whiteley	
4,452,304	A	*	6/1984	Barrier et al.	166/70
4,478,279	A	*	10/1984	Puntar et al.	166/121
4,516,634	A	*	5/1985	Pitts	166/120
4,545,434	A	*	10/1985	Higgins	166/217
4,646,829	A	*	3/1987	Barrington et al.	166/125
4,825,945	A	*	5/1989	Smith	166/87.1
4,934,459	A		6/1990	Baugh et al.	
5,020,590	A	*	6/1991	McLeod	166/77.4
5,058,672	A		10/1991	Cochran	
5,170,845	A	*	12/1992	Gay et al.	166/374
5,201,371	A	*	4/1993	Allen	166/325
5,305,828	A	*	4/1994	White et al.	166/120
5,320,181	A	*	6/1994	Lantier et al.	166/386
5,501,280	A	*	3/1996	Brisco	166/373
5,782,297	A		7/1998	Samuels et al.	
5,857,524	A		1/1999	Harris et al.	
5,901,787	A	*	5/1999	Boyle	166/135
6,497,291	B1		12/2002	Szarka	
7,117,737	B2		10/2006	Sallee et al.	
7,308,934	B2	*	12/2007	Swagerty et al.	166/177.5
7,383,891	B2		6/2008	Fay et al.	
7,533,728	B2	*	5/2009	Winslow et al.	166/318
8,539,976	B1	*	9/2013	Rodgers et al.	137/512
9,133,672	B2	*	9/2015	Nguyen et al.	
2006/0102361	A1		5/2006	Fay et al.	
2008/0001111	A1		1/2008	Ross	
2008/0169097	A1	*	7/2008	Bolding et al.	166/263
2008/0314583	A1	*	12/2008	Xu	166/123
2010/0258319	A1	*	10/2010	Nguyen et al.	166/373
2011/0011575	A1	*	1/2011	Nguyen et al.	166/87.1
2011/0079399	A1	*	4/2011	Nguyen et al.	166/373
2011/0114321	A1	*	5/2011	Guidry et al.	166/308.1

FOREIGN PATENT DOCUMENTS

GB	2291449	1/1996
WO	2009067298 A1	5/2009

OTHER PUBLICATIONS

Great Britain Examination Report for GB Application No. GB1016480.4 dated Aug. 7, 2012.

Great Britain Examination Report for GB Application No. GB1219398.3 dated Nov. 29, 2012.

Great Britain Examination Report for GB Application No. GB1016480.4 dated Dec. 18, 2012.

PCT International Search Report & Written Opinion for PCT/US2009/037731, dated Sep. 4, 2009.

* cited by examiner

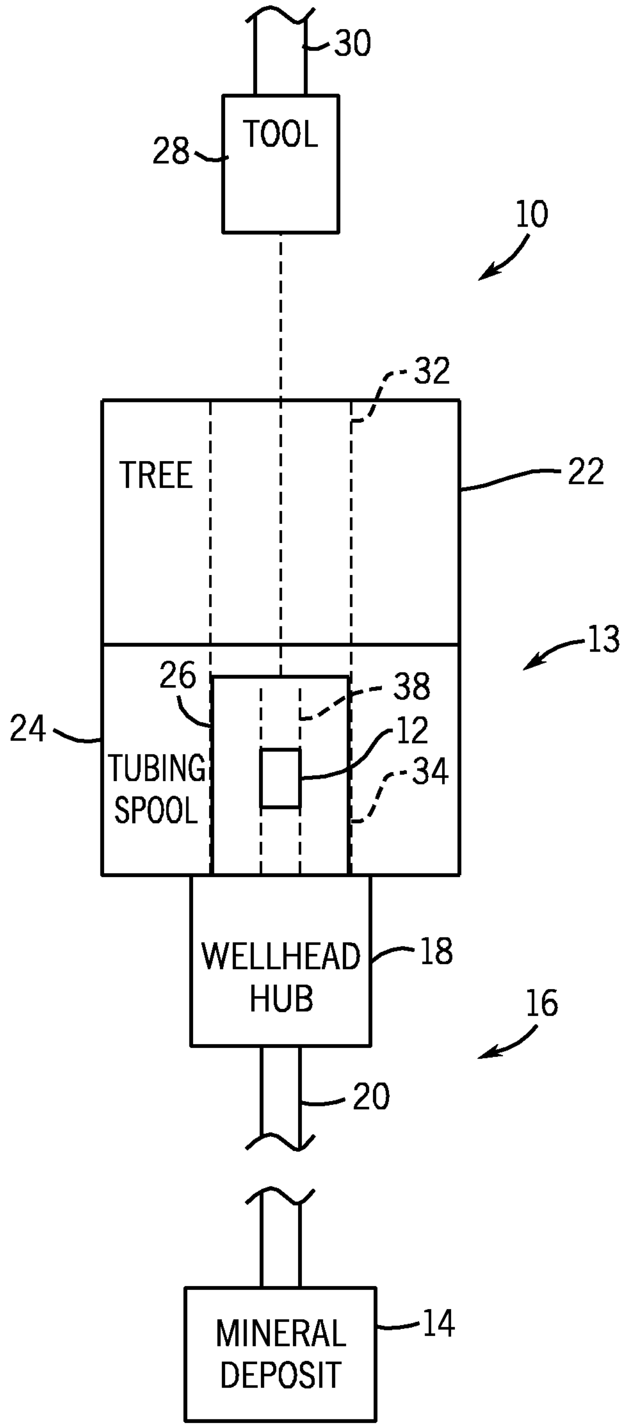

30
TOOL
28
10
32
TREE
22
13
26
38
24
12
TUBING
SPOOL
34
WELLHEAD
HUB
18
16
20
MINERAL
DEPOSIT
14

FIG. 1

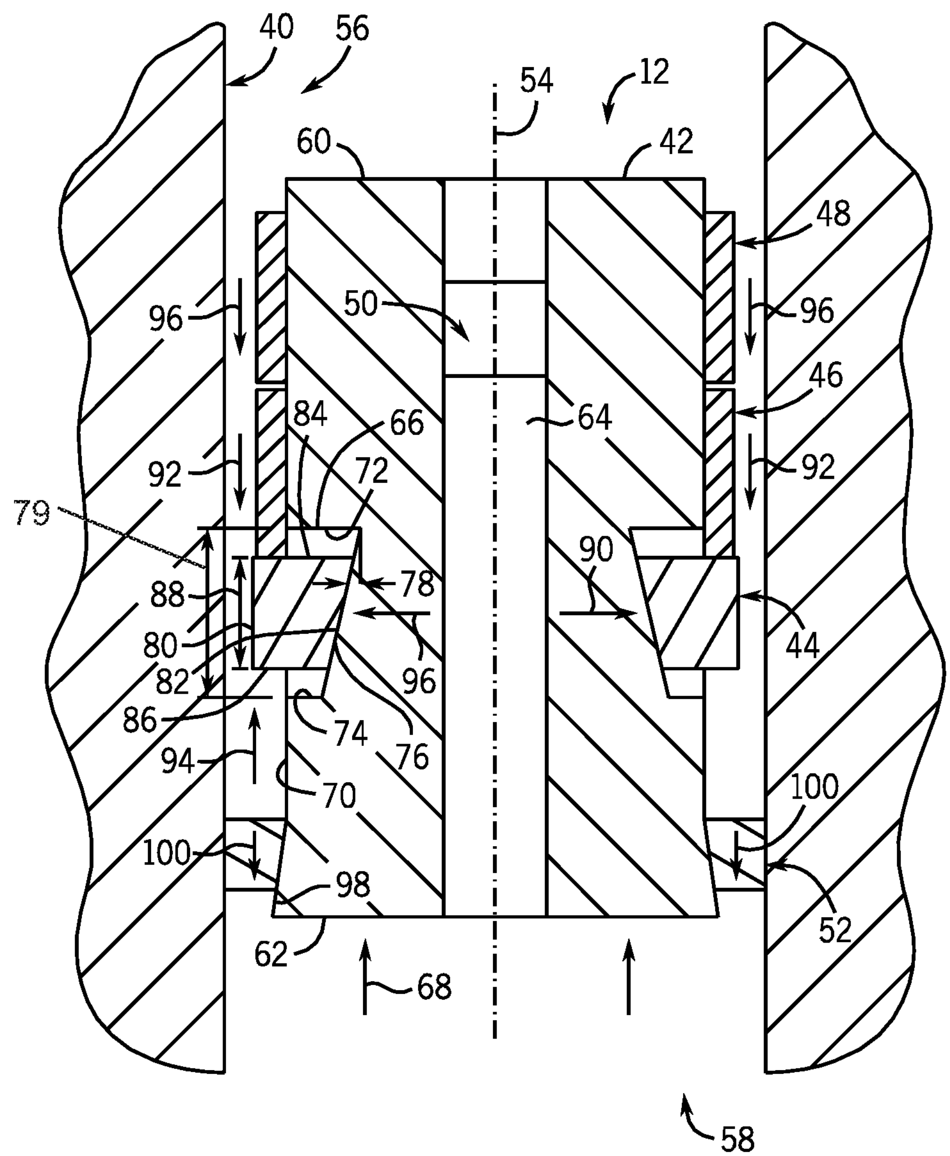

40
56
54
12
60
42
48
96
50
96
46
64
84
66
92
72
92
79
90
88
78
80
44
96
82
86
74
76
94
70
100
100
98
52
62
68
58

FIG. 2

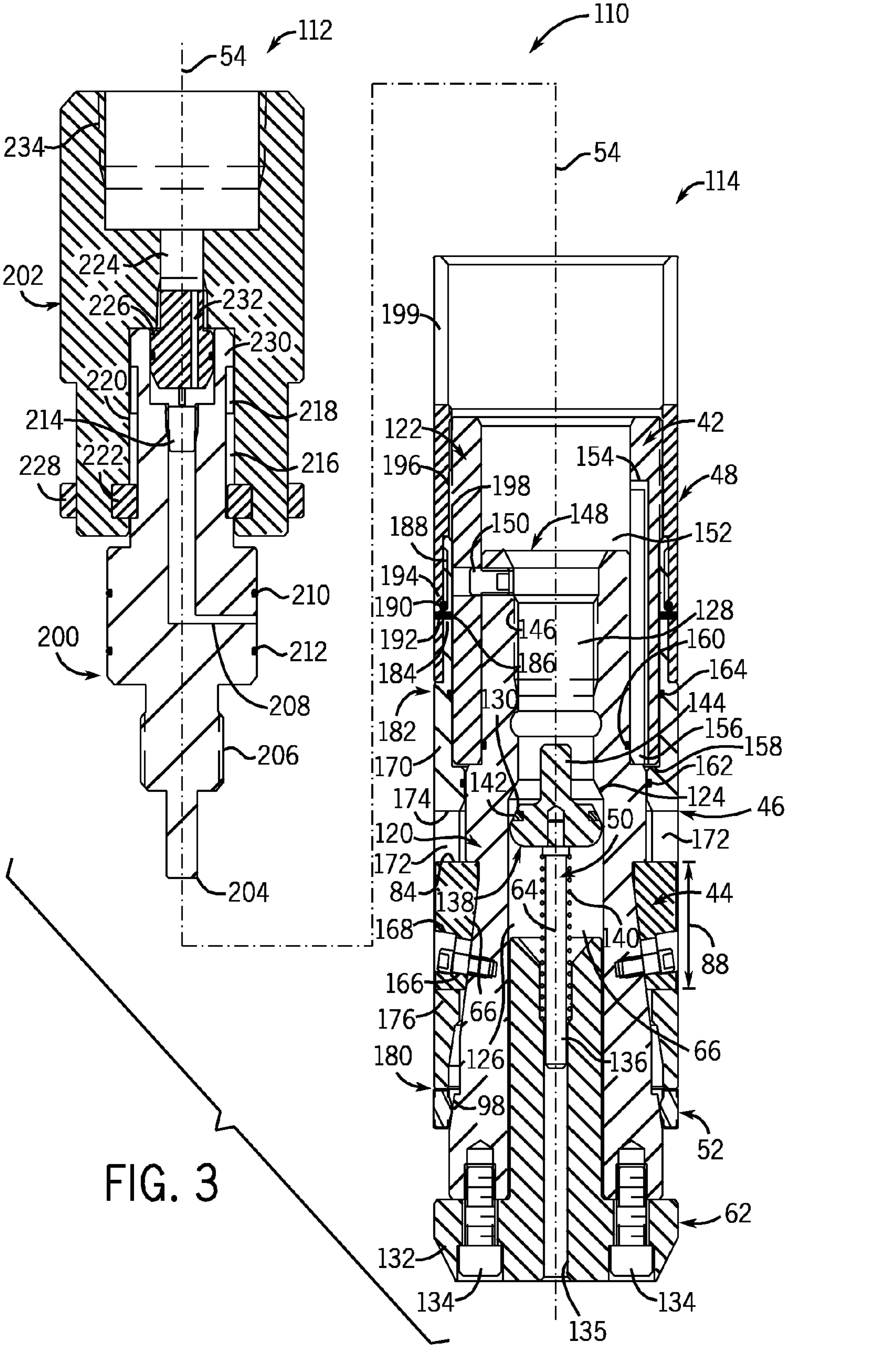

112
54
110
54
114
234
202
224
226
232
230
220
218
214
216
228
222
210
200
212
208
206
204
199
122
42
196
154
198
48
188
150
148
152
194
190
128
146
192
184
186
160
164
182
130
144
156
158
170
162
142
124
174
46
50
120
172
172
84
138
64
44
168
140
88
166
66
176
66
180
126
136
66
98
52
62
132
134
134
135

FIG. 3

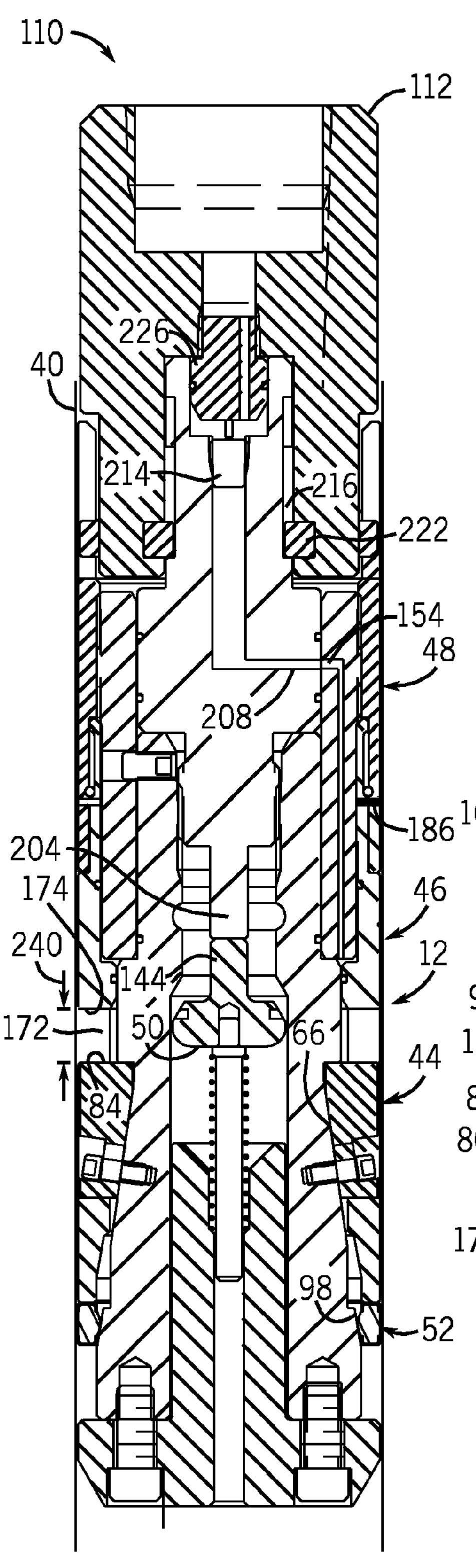

110
112
226
40
214
216
222
154
48
208
186
204
174
46
240
12
144
172
50
66
44
84
98
52

FIG. 4A

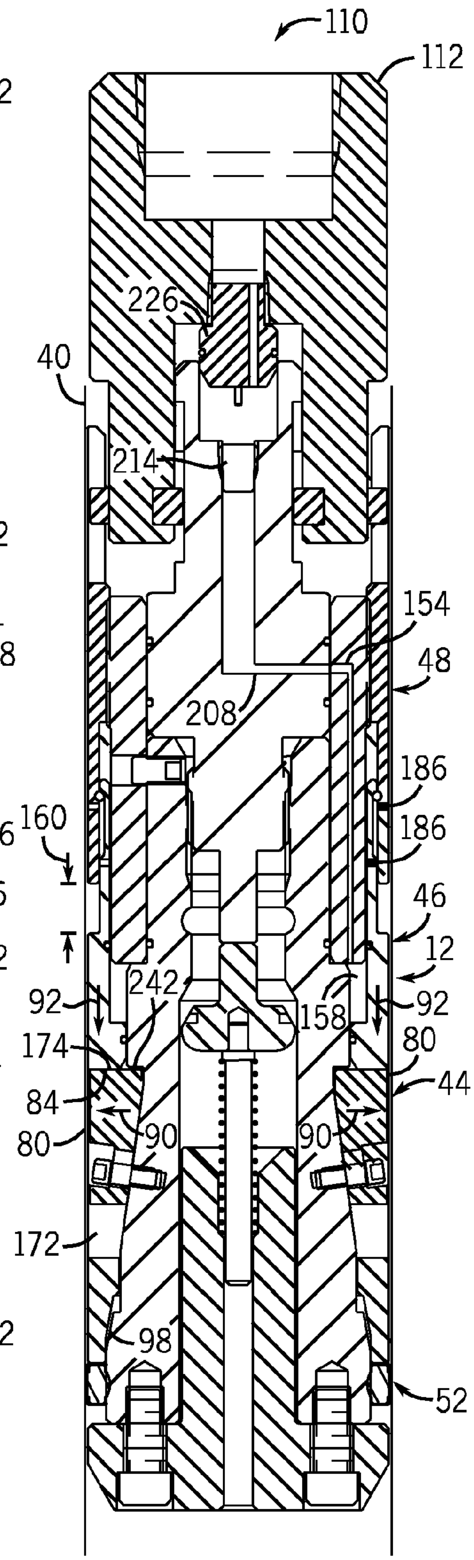

110
112
226
40
214
154
48
208
186
160
186
46
12
92
242
92
158
174
80
84
44
80
90
90
172
98
52

FIG. 4B

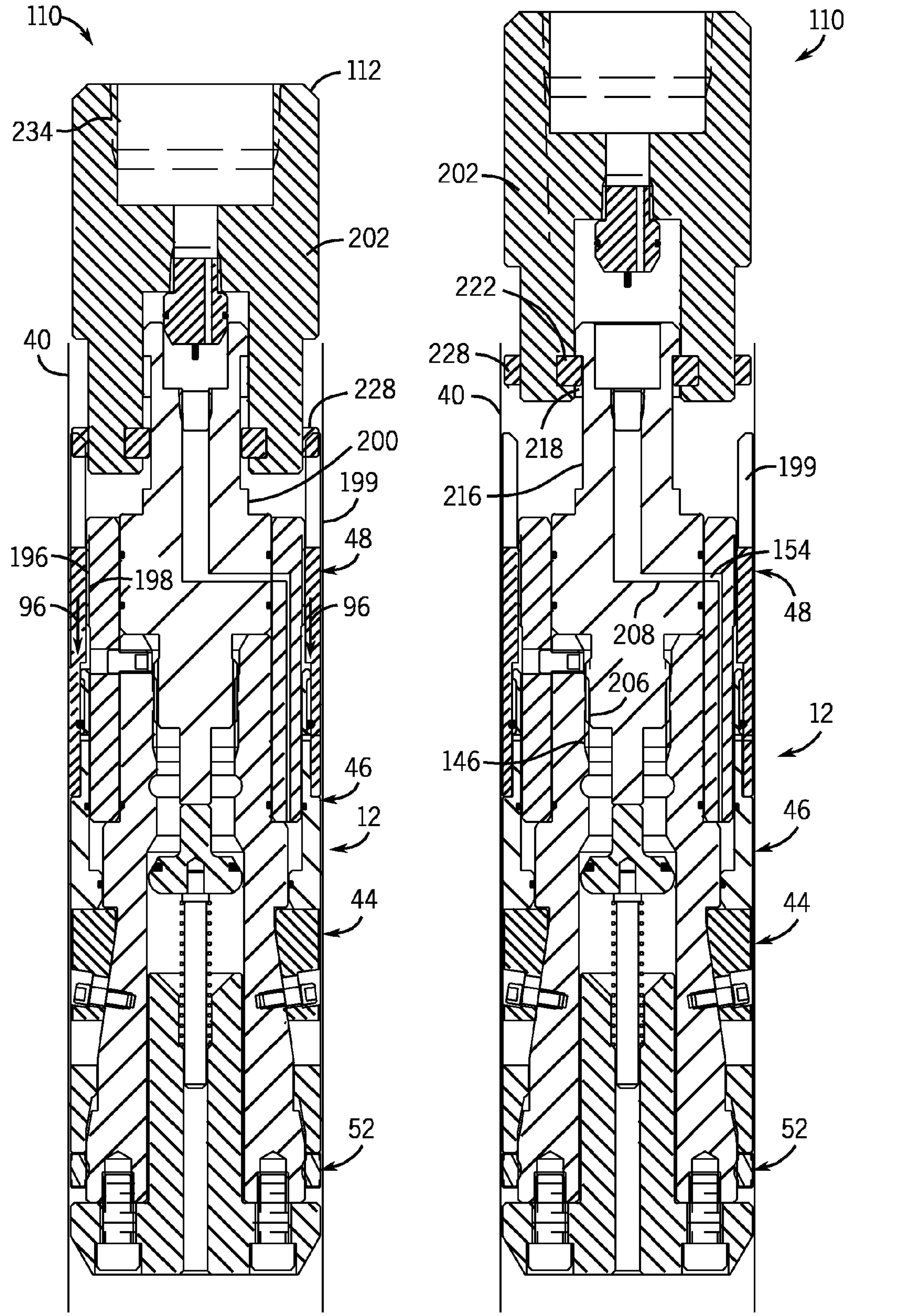

110
112
234
202
40
228
200
199
196
198
48
96
96
46
12
44
52
110
202
222
228
40
218
216
199
154
48
208
206
12
146
46
44
52

FIG. 4C FIG. 4D

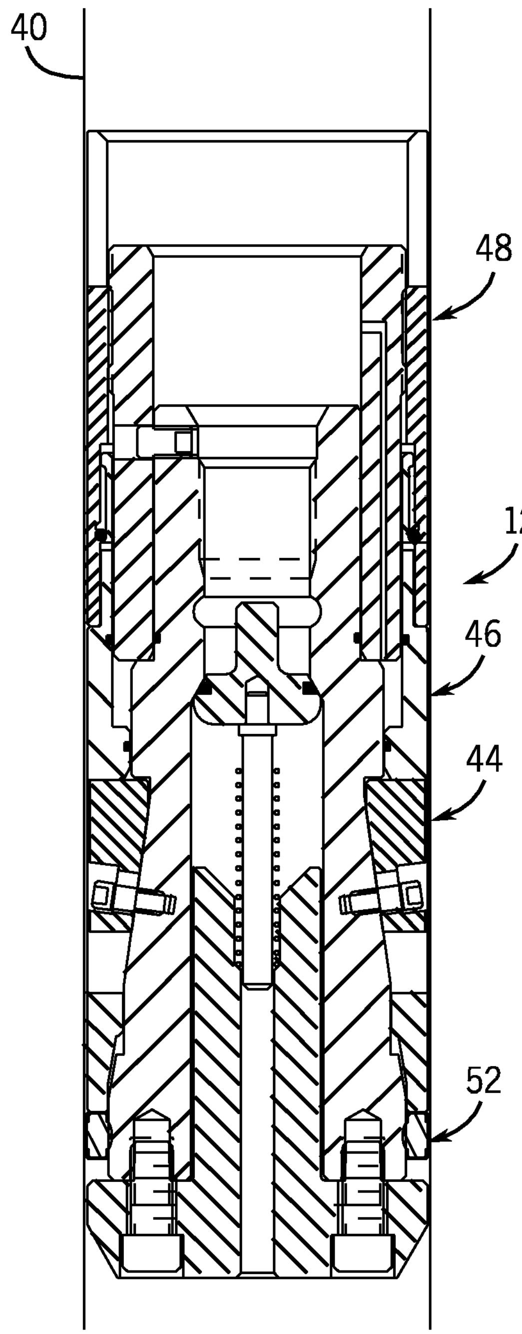


FIG. 4E

STRAIGHT-BORE BACK PRESSURE VALVE

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Non-Provisional patent application Ser. No. 12/920,826, entitled "Straight-Bore Back Pressure Valve", filed on Sep. 2, 2010, which is herein incorporated by reference in its entirety, and which claims priority to and benefit of PCT Application No. PCT/US09/37731 entitled "Straight-Bore Back Pressure Valve", filed on Mar. 19, 2009, which is herein incorporated by reference in its entirety, and which claims priority to and benefit of U.S. Provisional Patent Application No. 61/043,580, entitled "Straight-Bore Back Pressure Valve", filed on Apr. 9, 2008, which is herein incorporated by reference in its entirety.

BACKGROUND

This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the present invention, which are described and/or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present invention. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

As will be appreciated, oil and natural gas have a profound effect on modern economies and societies. In order to meet the demand for such natural resources, numerous companies invest significant amounts of time and money in searching for and extracting oil, natural gas, and other subterranean resources from the earth. Particularly, once a desired resource is discovered below the surface of the earth, drilling and production systems are employed to access and extract the resource. These systems can be located onshore or offshore depending on the location of a desired resource. Further, such systems generally include a wellhead assembly that is used to extract the resource. These wellhead assemblies include a wide variety of components and/or conduits, such as various control lines, casings, valves, and the like, that are conducive to drilling and/or extraction operations. In drilling and extraction operations, in addition to wellheads, various components and tools are employed to provide for drilling, completion, and the production of mineral resources. For instance, during drilling and extraction operations seals and valves are often employed to regulate pressures and/or fluid flow.

A wellhead system often includes a tubing hanger or casing hanger that is disposed within the wellhead assembly and configured to secure tubing and casing suspended in the well bore. In addition, the hanger generally regulates pressures and provides a path for hydraulic control fluid, chemical injections, or the like to be passed through the wellhead and into the well bore. In such a system, a back pressure valve is often disposed in the hanger bore and/or a similar bore of the wellhead. The back pressure valve plugs the bore to block pressures of the well bore from manifesting through the wellhead.

Typically, the back pressure valve is provided separately from the hanger, and is installed after the hanger has been landed in the wellhead assembly. In other words, the hanger is run down to the wellhead, followed by the installation of the back pressure valve. One resulting challenge includes installing the back pressure valve into the hanger bore in

context of high pressures in the bore. Accordingly, installation of the back pressure valve may include the use of several tools and a sequence of procedures to set and lock the seal. Unfortunately, each of the sequential running procedures may consume a significant amount of time and money. Further, securing the back pressure valve generally includes complementary engagement features in the bore itself. The bore typically includes shoulders, grooves, notches, or similar features that are engaged by portions of the back pressure valve. Thus, the design of the bore is configured to accommodate a specific back pressure valve design. Typically, the back pressure valve and bore are designed specifically for use with one another, thereby, adding yet another level of complexity to the overall design of the wellhead.

BRIEF DESCRIPTION OF THE DRAWINGS

Various features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying figures in which like characters represent like parts throughout the figures, wherein:

FIG. **1** is a block diagram that illustrates a mineral extraction system in accordance with an embodiment of the present technique;

FIG. **2** is a block diagram that illustrates a back pressure valve in accordance with an embodiment of the present technique;

FIG. **3** is an exploded cross-sectioned view of a back pressure valve system in accordance with an embodiment of the present technique; and

FIG. **4**A-**4**E are cross-sectioned views of the back pressure valve system in accordance with embodiments of the present technique.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

One or more specific embodiments of the present invention will be described below. These described embodiments are only exemplary of the present invention. Additionally, in an effort to provide a concise description of these exemplary embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

When introducing elements of various embodiments of the present invention, the articles "a," "an," "the," and "said" are intended to mean that there are one or more of the elements. The terms "comprising," "including," and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements. Moreover, the use of "top," "bottom," "above," "below," and variations of these terms is made for convenience, but does not require any particular orientation of the components.

Certain exemplary embodiments of the present technique include a system and method that each addresses one or more of the above-mentioned inadequacies of conventional sealing systems and methods. As explained in greater detail below, the disclosed embodiments include a back pressure valve that can be installed into a straight bore. More specifically, the back pressure valve is installed into a portion of a bore that does not include engagement features to secure the back pressure valve in the bore. Accordingly, the back pressure valve is secured against the generally smooth/flat walls of the bore, as opposed to grooves, shoulders, or similar features that are typically employed to secure a back pressure valve, or a similar valve, in a bore. As a result, the exemplary back pressure valve may be inserted into a large variety of tubing hangers with varying bore profiles. In certain embodiments, the back pressure valve includes a friction member that is expanded radially to secure the back pressure valve into the bore. In some embodiments, the friction member is moved longitudinally via hydraulic pressure exerted on an outer sleeve, and/or secured in a locked position via a locking ring that is rotated into position to block the outer sleeve in position when the hydraulic pressure is reduced. Before discussing embodiments of the system in detail, it may be beneficial to discuss a system that may employ such a back pressure valve.

FIG. **1** is a block diagram that illustrates a mineral extraction system **10** including a back pressure valve (BPV) **12** in accordance with embodiments of the present technique. The illustrated mineral extraction system **10** can be configured to extract various minerals and natural resources, including hydrocarbons (e.g., oil and/or natural gas), or configured to inject substances into the earth. In some embodiments, the mineral extraction system **10** is land-based (e.g., a surface system) or subsea (e.g., a subsea system). In the illustrated embodiment, the system **10** includes a wellhead **13** coupled to a mineral deposit **14** via a well **16**, wherein the well **16** includes a wellhead hub **18** and a well-bore **20**.

The wellhead hub **18** generally includes a large diameter hub that is disposed at the termination of the well bore **20**. The wellhead hub **18** provides for the connection of the wellhead **13** to the well **16**. In some embodiments, the wellhead **13** includes a connector that is coupled to a complementary connector of the wellhead hub **18**. For example, in one embodiment, the wellhead hub **18** includes a DWHC (Deep Water High Capacity) hub manufactured by Cameron, headquartered in Houston, Tex., and the wellhead **13** includes a complementary collet connector (e.g., a DWHC connector), also manufactured by Cameron.

The wellhead **13** typically includes multiple components that control and regulate activities and conditions associated with the well **16**. In some embodiments, the wellhead **13** generally includes bodies, valves and seals that route produced minerals from the mineral deposit **14**, provides for regulating pressure in the well **16**, and provides for the injection of chemicals into the well bore **20** (down-hole). For example, in the illustrated embodiment, the wellhead **13** includes what is colloquially referred to as a christmas tree **22** (hereinafter, a tree), a tubing spool **24**, and a hanger **26** (e.g., a tubing hanger or a casing hanger). The system **10** may include other devices that are coupled to the wellhead **13**, and devices that are used to assemble and control various components of the wellhead **13**. For example, in the illustrated embodiment, the system **10** includes a tool **28** suspended from a drill string **30**. In certain embodiments, the tool **28** includes a running tool that is lowered (e.g., run) from an offshore vessel to the well **16** and/or the wellhead **13**. In other embodiments, such as surface systems, the tool **28** may include a device suspended over and/or lowered into the wellhead **13** via a crane or other supporting device.

The tree **22** generally includes a variety of flow paths (e.g., bores), valves, fittings, and controls for operating the well **16**. For instance, in some embodiments, the tree **22** includes a frame that is disposed about a tree body, a flow-loop, actuators, and valves. Further, the tree **22** generally provides fluid communication with the well **16**. For example, in the illustrated embodiment, the tree **22** includes a tree bore **32**. The tree bore **32** provides for completion and workover procedures, such as the insertion of tools (e.g., the hanger **26**) into the well **16**, the injection of various chemicals into the well **16** (down-hole), and the like. Further, minerals extracted from the well **16** (e.g., oil and natural gas) are generally regulated and routed via the tree **22**. For instance, the tree **22** may be coupled to a jumper or a flowline that is tied back to other components, such as a manifold. Accordingly, in such an embodiment, produced minerals flow from the well **16** to the manifold via the wellhead **13** and/or the tree **22** before being routed to shipping or storage facilities.

The tubing spool **24** provides a base for the wellhead **24** and/or an intermediate connection between the wellhead hub **18** and the tree **22**. Typically, the tubing spool **24** (also referred to as a tubing head) is one of many components in a modular subsea or surface mineral extraction system **10** that are run from an offshore vessel and/or a surface installation system. As illustrated, the tubing spool **24** includes the tubing spool bore **34**. The tubing spool bore **34** connects (e.g., enables fluid communication between) the tree bore **32** and the well **16**. Thus, the tubing spool bore **34** provides access to the well bore **20** for various completion procedures, worker procedures, and the like. For example, components can be run down to the wellhead **13** and disposed in the tubing spool bore **34** to seal-off the well bore **20**, to inject chemicals down-hole, to suspend tools down-hole, and/or to retrieve tools from down-hole.

As will be appreciated, the well bore **20** may contain elevated pressures. For instance, in some systems, the well bore **20** may include pressures that exceed 10,000 pounds per square inch (PSI), that exceed 15,000 PSI, and/or that even exceed 20,000 PSI. Accordingly, mineral extraction systems **10** typically employ various mechanisms, such as seals, plugs and valves, to control and regulate the well **16**. In some instances, plugs and valves are employed to regulate the flow and pressures of fluids in various bores and channels throughout the mineral extraction system **10**. The illustrated hanger **26** (e.g., tubing hanger or casing hanger), for example, is typically disposed within the wellhead **13** to secure tubing and casing suspended in the well bore **20**, and to provide a path for hydraulic control fluid, chemical injections, and the like. The hanger **26** includes a hanger bore **38** that extends through the center of the hanger **26**, and that is in fluid communication with the tubing spool bore **34** and the well bore **20**. Unfortunately, if left unregulated, pressures in the bores **20** and **34** can manifest through the wellhead **13**. Accordingly, the back pressure valve (BPV) **12** is often seated and locked in the hanger bore **38** to regulate the pressure. Valves similar to the illustrated back pressure valve **12** can be used throughout the mineral extraction system **10** to regulate fluid and/or gas pressures and flow paths.

In the context of the hanger **26**, the back pressure valve **12** can be installed into the hanger **26**, or a similar location, before the hanger **26** is installed in the wellhead **13**, or may be installed into the hanger **26** after the hanger **26** has been installed in the wellhead **13** (e.g., landed in the tubing spool bore **34**). In the latter case, the hanger **26** is typically run down and installed into the subsea wellhead **13** (or a similar surface wellhead), followed by the installation of the back pressure valve **12**. During installation of the back pressure valve **12**, pressure in the well bore **20** may exert a force (e.g., a backpressure) on the lower portion of the back pressure valve **12**. Unfortunately, the backpressure may increase the difficulty of installing the back pressure valve **12**. For example, the backpressure may resist the installation of the back pressure valve **12**. Although typical embodiments of the hanger bore **38** include shoulders, grooves, notches, or similar features that are engaged by portions of the back pressure valve **12**, in embodiments of the system **10**, the back pressure valve **12** is disposed in a portion of the hanger bore **38** that is a straight bore. Accordingly, the system and methods discussed in greater detail below provide a system and method including disposing the back pressure valve **12** in the straight hanger bore **38**, and/or a similar straight bore (e.g., a tubing or casing pipe bore).

FIG. **2** is a block diagram that illustrates an embodiment of the back pressure valve (BPV) **12** disposed in a bore **40** in accordance with embodiments of the present techniques. In the illustrated embodiment, the BPV **12** includes a body **42**, a friction member **44**, an outer sleeve **46**, a lock ring **48**, a plunger **50**, and a seal **52**.

The bore **40** includes a straight bore (e.g., a full-bore). A straight bore can be defined as a bore having an internal diameter including generally constant or uniform surfaces that do not include engagement/retention features such as shoulders, grooves, notches, or the like. For example, in some embodiments, the internal surface of the bore includes straight or flat walls that are generally parallel to a longitudinal axis of the bore. In some embodiments, the bore **40** includes a generally cylindrical bore formed from casing, tubing, or a bore internal to the system **10**, such as the hanger bore **38**. For example, in one embodiment, the bore **40** includes the hanger bore **38**, or a similar bore (e.g., a tubing or casing pipe bore), having a generally consistent internal diameter along its length.

Further, in one embodiment the bore **40** is straight along its entire length, whereas in other embodiment, the bore **40** is straight along some portion but not all of its length. For example, the bore **40** is straight at least in the portion of the bore **40** where the BPV **12** is seated, in one embodiment. In such an embodiment, other portions of the bore **40** may include engagement features that are configured for securing other valves and tools, for instance.

The surface of the bore **40** generally does not include any significant physical features or preparation, in some embodiments. For example, in one embodiment, the bore **40** includes a smooth unfinished surface. This includes the standard finish of the body that forms the bore **40**, such as, for example, the interior of the casing, the tubing, and the hanger bore **38**. However, in other embodiments, the internal surface of the bore **40** includes a modified surface. In other words, the internal surface of the bore **40** includes some form of preparation of the surface, but still does not include engagement/retention features, such as shoulders, grooves, notches, or the like. In one embodiment, the modified surface includes a scored surface, or otherwise coarse finish to encourage friction (e.g., increase the coefficient of friction) between the internal surface of the bore **40** and complementary features of the BPV **12**. In another embodiment, the modified surface includes polishing, smoothing, or otherwise preparing the surface for contact with the back pressure valve **12**.

In the illustrated embodiment, the bore **40** includes a longitudinal axis **54** running the length of the bore **40**. In operation, the BPV **12** is located along the longitudinal axis **54** and regulates pressures between an upper bore portion **56** and a lower bore portion **58**. The upper bore portion (e.g., a downstream and bore portion) **56** includes a portion of the bore **40** toward an upper end of the wellhead **13** and the lower bore portion (e.g., a downstream bore portion) **58** includes a portion of the bore **40** that is on an opposite end of the well-head **13**. For example, the lower bore portion **58** includes an end exposed and/or in the direction of the well-bore **20** and/or the mineral deposit **14**, in certain embodiments.

The body **42** of the BPV **12** includes an upper end **60** (e.g., downstream end), a lower end **62** (e.g., upstream end), a plunger bore **64**, and a recess **66**. The upper end **60** of the body **42** generally is exposed to and faces the upper bore portion **56** when installed. Similarly, the lower end **62** of the body generally is exposed to and faces the lower bore portion **58**. Accordingly, when installed, the lower end of the BPV **12** is exposed to the pressures associated with the lower bore portion **58**. These pressures typically include pressures from the well bore **20**, the mineral deposit **14**, fluids and gases injected down-hole and the like. The pressures generally act on the lower end **62** in the direction of the arrows **68** (e.g., toward the upper bore portion **56**).

The plunger bore **64** includes a bore that extends through the length of the body **42** of the BPV **12**. The plunger bore **64** generally includes a path for the regulation of pressure between the upper bore portion **56** and the lower bore portion **58**. For example, when opened (e.g., not occluded) fluids and gases on either side of the BPV **12** can flow back and forth to maintain a balanced pressure between the upper bore portion **56** and the lower bore portion **58**. This may be particularly useful during installation and removal of the BPV **12** when the pressure is balanced to enable moving of the BPV **12** within the bore **40** and along the longitudinal axis **54** without additional loading to overcome the longitudinal forces, such as those acting on the lower end **62** of the BPV **12**. When closed (e.g., occluded) the BPV **12** generally occludes the bore to maintain a pressure differential between the upper bore portion **56** and the lower bore portion **58**. More specifically, in an embodiment in which the plunger **50** includes a unilateral check valve, the BPV **12** is typically configured to retain an elevated pressure in the lower bore portion **58**.

As mentioned briefly above, the plunger **50** is typically employed to regulate the flow of fluids and gases through the BPV **12**. More specifically, the plunger **50** includes an open position and a closed position in certain embodiments. For example, in one embodiment, the plunger **50** includes a sealing portion (e.g., a bell) that is configured to engage a complementary sealing surface or feature in the plunger bore **64**. In a closed position, the sealing portion of the plunger **50** engages the sealing surface/feature in the plunger bore **64** to occlude the plunger bore **64**. In an open position, the sealing portion of the plunger **50** is urged/located away from the sealing surface of the plunger bore **64**, thereby enabling fluid and gases to pass through the plunger bore **64**. Certain embodiments of the plunger **50** and the plunger bore **64** are discussed in more detail below with regard to FIGS. **3** and **4A-4E**.

The recess **66** generally includes one or more indentations in an external surface **70** of the body **42**. In one embodiment, the recess **66** includes a single groove about an external surface (e.g., circumference) **70** of the body **42**. In other embodiments, the recess **66** includes one or more separate recessed sections about the external surface **70** of the body **42**. In the illustrated embodiment, the recess **66** includes a groove that extends around the circumference of the body **42** and that includes an upper face **72**, a lower face **74** and an internal face **76**. The internal face **76** includes an angle (e.g., a taper) relative to the longitudinal axis **54**, in the illustrated embodiment. For example, the internal face **76** includes a smaller diameter proximate the upper face **72** and the upper end **60** of the body **42**, and includes a larger diameter proximate the lower face **74** and the lower end **62** of the body **24** (e.g., a conical section of the body **42**). In other words, the internal face **76** includes a taper that increases in diameter from the upper face **72** to the lower face **74**. Thus, the internal face **76** is oriented at an angle **78** relative to the longitudinal axis **54**. As is discussed in greater detail below, the angle **78** may include any angle suitable for expanding the friction member **44**. For example, in one embodiment, the angle **78** is between about 5 degrees and 10 degrees. However, in other embodiments, the angle **78** may be greater than about 10 degrees or less than about 5 degrees. Further, a height **79** of the recess **66** is defined by the distance between the upper face **72** and the lower face **74**.

The friction member **44** generally includes one or more devices that are employed to secure the BPV **12** to the bore **40**. More specifically, in some embodiments, the friction member **44** includes one or more members (discussed in more detail below) that are expanded in a radial manner/direction to contact the walls of the bore **40**, thereby securing the BPV **12** to the bore **40**. In certain embodiments, an outer surface (e.g., friction surface) of the friction member **44** directly contacts a straight portion of the bore **40**, thereby securing the BPV **12** in the bore without the aid of any engagement/retention features, such as shoulders, grooves, notches, or the like.

In the illustrated embodiment, the friction member **44** includes a friction face **80**, an internal face **82**, an upper face **84**, and a lower face **86**. The upper face **84** and lower face **86** are proximate the upper face **72** and lower face **74**, respectively, of the recess **66** in the body **42**. As depicted in the illustrated embodiment, a height **88** (e.g., the distance between the upper face **84** and the lower face **86**) of the friction member **44** is less than the height **79** of the recess **66**. Accordingly, in one embodiment, the friction member **44** is capable of moving longitudinally (e.g., a long the longitudinal axis **54**) relative to the recess **66** and the body **42** of the BPV **12**.

The internal face **82** generally includes a profile that is complementary to the profile of the internal face **72** of the body **42**. In the illustrated embodiment, for example, the internal face **82** of the friction member **44** includes a taper that is complementary to the taper (angle **78**) of the internal face **76**. In other words, the internal face includes a profile (taper) that increases in diameter from the upper face **84** to the lower face **86**. Accordingly, in one embodiment, movement of the friction member **44** in a longitudinal direction (e.g., along the longitudinal axis **54**) relative to the body **42** and the recess **66** causes the friction member to expand and/or contract radially. For example, in an embodiment where the friction member **44** is located proximate the upper face **72** of the recess **66** and urged toward the lower face **74** of the recess **66**, the friction member **44** expands radially in the direction of the arrows **90**. As is discussed below, the urging force to displace the friction member **44** can be provided downward on the friction member **44** (e.g., from the outer sleeve **46**) or upward on the body **42** (e.g., the pressure acting on the lower end **62** of the body **42**), in certain embodiments. In one embodiment, force may be applied in the opposite direction to urge the friction member **44** upward (e.g., toward the upper face **72** of the recess **66** and urge the friction member inward, in a direction opposite the arrows **90**. Further, it will be appreciated that although the illustrated embodiment includes urging the friction member downward (e.g., toward the lower face **74** and toward the lower bore portion **58**) to expand the friction member radially, other embodiments include a similar configuration wherein urging the friction member **44** in an upward direction expands the friction member **44** radially. For example, the taper can be reversed in one embodiment such that the diameter is larger proximate the upper face **72** of the recess **66** and smaller proximate the lower face **74**. In any of the embodiments, expanding the friction member **44** causes the friction face **80** of the friction member **44** to contact the internal surface of the bore **40**.

The friction face **80** includes the face located on the outside of the friction member **44**. Generally, the friction face **80** contacts the walls of the bore **40** when the friction member **44** is expanded in a radial direction, represented by the arrows **90**. In certain embodiments, the friction face **80** includes one or more surface features conducive to securing the friction member **44**, and, thus, the BPV **12** to the bore **40**. Generally, the friction face **80** includes a surface that provides a coefficient of friction sufficient to secure the BPV **12** in the bore **40** in light of the pressures experienced across the BPV **12**. For example, in one embodiment, the friction face **80** includes a coarse finish. The coarse finish is provided by scoring, or sanding the friction face **80**, in one embodiment. In another embodiment, the coarse finish is provided by coating the friction face **80** with a composite material. For example, the friction face **80** includes a coating of a material having a hardness that is less than the hardness of the surface of the bore **40**, in one embodiment.

In other embodiments, the surface features include indentations and/or patterns of indentations in the friction face **80**. In one embodiment, the friction face **80** includes a plurality of grooves that provide localized areas of high surface contact forces when the friction member **44** is expanded radially against the surface of the bore **40**. These localized areas of force enable the friction member **44** to bite into the interior of the bore **40**. For example, in one embodiment, the indentations form rows and/or columns of teeth.

In some embodiments, the friction face **80** includes a generally flat and/or smooth surface. For example, in one embodiment, the friction face **80** includes an unfinished or polished surface. In such an embodiment, the increased contact area between the friction face **80** and the surface of the bore **40** provides the friction to secure the friction member **44** and the BPV **12** to the bore **40**.

The friction face **80**, in some embodiments, includes any combination of the surface features discussed above. For example, in one embodiment, the friction face **80** includes teeth like features in one region, a smooth finish in other regions, and a coating over at least a portion of the regions. In another embodiment, the friction face **80** includes a combination of recesses (e.g., teeth and grooves) and a coating, for example.

Further, the friction face **80** includes a profile that is conducive to generating a friction between the friction member **44** and the bore **40**. In one embodiment, the friction face **80** includes a profile that is similar to the profile of the bore **40**. For example, in the illustrated embodiment, the profile of the friction face **80** includes a surface that is in generally parallel to the surface of the bore **40**. In other words, the surface of the friction face **80** includes at least a portion that is parallel to the longitudinal axis **54** (e.g., cylindrical exterior).

The friction member **44** is formed from one or more devices that are capable of being expanded radially, as discussed above. In some embodiments, the friction member **44** includes one or more rings, one or more segments, one or more locking dogs, or a combination thereof. For example, in one embodiment, the friction member **44** includes a C-ring that is positioned in the recess **66**. In another embodiment, the C-ring includes one or more segments along its exterior that are configured to contact the surface of the bore **40**. In such embodiments, the recess **66** may include a groove that extends around circumference of the body **42**. In another embodiment, the friction member **44** includes one or more locking segments that are positioned in one or more recesses **66** about the circumferences. For example, in one embodiment, the segments are disposed about a single groove forming the recess **66**. In another embodiment, the recess **66** includes a plurality of separate indentations that are configured to accept one or more of the segments forming the friction member **44**. For example, the friction member **44** is formed form several segments that are not joined to one another in one embodiment. In another embodiment, the segments are coupled to one another by a common member. For example, in one embodiment, the friction ring **44** includes a plurality of segments coupled to a common ring. It will be appreciated that the friction member **44** may includes any mechanism or device configured to expand radially to provide a securing/friction force between the BPV **12** and an internal surface of the bore **40**.

The outer sleeve **46** generally includes a device or mechanism that exerts a force on the friction member **44**. More specifically, in certain embodiments, the outer sleeve **46** exerts a longitudinal force (e.g., a force parallel to the longitudinal axis **54**) on the friction member **44** that causes the friction member **44** to expand radially. For example, in the illustrated embodiment, urging the outer sleeve **46** in the direction of arrows **92** generates an axial load on at least a portion of the upper face **84** of the friction member **44**. The axial load urges the friction member **44** in the direction of the arrows **92**, thereby causing radial expansion of the friction member **44**, as discussed above. Although the outer sleeve **46** is located above the friction member **44** in the illustrated embodiment, all or at least a portion of the outer sleeve **46** may be located below the friction member **44** in other embodiments. For example, in an embodiment where an axial load is delivered to the lower face **86** of the friction member **44**, at least a portion of the outer sleeve may be located below the friction member **44**. For example, as discussed in greater detail below with regard to FIGS. **3** and **4A-4**E, a portion of the outer sleeve **46** is located below the friction member **44** to provide a force in the direction of arrows **94** to enable the friction member **44** to contract radially. In another embodiment, for example, the embodiment in which the taper is reversed, the axial force in the direction of the arrows **94** is employed to expand the friction member **44** radially.

The axial force provided by the outer sleeve is generated by hydraulic loading in some embodiments. For example, although not depicted in FIG. **3**, as discussed in greater detail below with regard to FIGS. **3** and **4A-4**E, the BPV **12** includes a hydraulic port that terminates in a chamber proximate the outer sleeve **46** such that energizing the hydraulic port and chamber exerts a force on the outer sleeve **46** in the direction of the arrows **92**, thereby providing the axial loading on the friction member **44**. Other embodiments may include similar forms of loading. For example, in one embodiment, the outer sleeve **46** is threaded to the body **42**, such that rotation of the outer sleeve **46** generates the axial force in the direction of the arrows **92**.

The lock ring **48** secures the position of outer sleeve **46** and, thus, the position of the friction member **44**, in certain embodiments. In one embodiment, the lock ring **48** is positioned against the outer sleeve **46** to block the outer sleeve **46** from moving upward (e.g., in the opposite direction of the arrows **92**). For example, in one embodiment, the lock ring **48** is threaded to the body **42** such that rotation of the lock ring **48** urges the locking ring downward (e.g., in the direction of the arrows **96**), and toward the outer sleeve **46**. In another embodiment, the lock ring **48** is urged into movement via a hydraulic arrangement similar to that discussed above with regard to the outer sleeve **46**. Accordingly, the lock ring **48** is urged/moved along the longitudinal axis **54** until it abuts the outer sleeve **46**, thereby securing the outer sleeve **46** in a position. In one embodiment, the outer sleeve **46** is secured in a locked position (e.g., a position holding the friction member **44** in the radially expanded position), for instance. In one embodiment, hydraulic pressure is employed to urge the outer sleeve **46** into engagement with the friction member **44**. The lock ring **48** is rotated until it is proximate or abutting the outer sleeve **46**, and the hydraulic pressure is released. With the hydraulic pressure is released, the outer sleeve **46** is blocked from moving a significant longitudinal distance by the lock ring **48**. Thus, the friction member **44** is held in position (e.g., an expanded position) via the outer sleeve **46** and the lock ring **48**.

In some embodiments, the BPV **12** includes one or more additional seals that block/regulate the pressures between the lower bore portion **58** and the upper bore portion **56**. For instance, in the illustrated embodiment, the BPV **12** includes a seal **52** disposed between the body **42** and the internal surface of the bore **40**. In one embodiment, the seal **52** includes a mechanical (e.g., MEC) seal. In another embodiment, the seal **52** includes an elastomer seal or similar seal.

The seal **52**, in some embodiments, is compressed within a region between the body **42** and the surface of the bore **40**. For example, in the illustrated embodiment, the seal **52** is disposed between a tapered surface **98** of the body **42** and the internal surface of the bore **40**. More specifically, the tapered surface **98** includes a diameter that increases proximate the lower end **62** of the body **42**. Accordingly, urging the seal **52** toward the lower end **62** and into engagement with the tapered face **98** (e.g., urging the seal in the direction of arrows **100**) compresses (e.g., seats) the seal **52** between the tapered face **98** and the internal surface of the bore **40**. In the seated position, the seal **52** provides a fluid seal that blocks fluids and gases from passing the BPV **12**.

In one embodiment, the seal **52** is seated by a member that is urged in the direction of the arrow **100** to compress and seat the seal **52**. For example, although not depicted in FIG. **2**, as discussed in further detail with regard to FIGS. **3** and **4A-4**E, in one embodiment, the outer sleeve **46** includes an extension that protrudes below the friction member **44** and into contact with the seal **52**. Accordingly, the outer sleeve **46** is urged in the direction of the arrows **92** to seat the seal **52**, in one embodiment. Further, as is discussed below, in one embodiment, the outer sleeve **46** includes a window such that movement of the outer sleeve **46** in the direction of the arrow **92**, first, seats the seal **52**, and, second, urges the friction member **44** into radial expansion.

Further, as discussed in detail with regard to FIGS. **3** and **4A-4**E, the BPV **12** is disposed (e.g., run) into position within the bore and/or installed via one or more running tools. More specifically, in certain embodiment, a running tool couples to the upper end **60** of the BPV **12** to provide operation of the BPV **12** during installation and retrieval, among other operations. For example, as discussed below, a running tool urges the plunger **50** to an open position, runs the BPV **12** to the desired location, provides hydraulic pressure to engage the outer sleeve **46** to seat the seal **52** and radially expand the friction member **44** into contact with the bore **40**, rotates the lock ring **48** to abut the outer sleeve **46**, releases hydraulic pressure, urges the plunger **50** into a closed position, and disconnects itself from the BPV **12** before being extracted from the bore **40**.

Although the previously discussed embodiments include operation of the friction member **44** as relying on longitudinal forces provided via the outer sleeve **46**, the lock ring **48**, and the body, it is worth noting that pressure acting on the BPV **12** provides for urging the friction member **44** into an expanded position. For example, in one embodiment, the pressure in the lower bore portion **58** acts on the lower end **62** of the body **42** of the BPV **12**. Such a loading provides for urging the body **42** upward relative to the friction member **44**. The upward movement along the longitudinal axis **54** provides for increasing the radial force (e.g., in the direction of arrows **90**) acting on the friction member **44**. Accordingly, as the pressure in the lower bore portion **58** increases, the radial expansion of the friction member **44** increases, thereby providing increased friction between the friction face **80** and the bore **40**. In other words, as the pressure in the lower portion increases **58**, the illustrated embodiment of the BPV **12** is secured even tighter into the bore **40**, helping to prevent the BPV **12** from becoming dislodged.

Turning now to FIGS. **3** and **4**A-**4**E, one embodiment of a BPV system **110** is depicted. More specifically, the illustrated embodiments include an installation sequence of a BPV system **110** including one embodiment of the BPV **12** and one embodiment of a back pressure valve (BPV) running tool **112**. The BPV **12** includes features similar to those discussed above with regard to the BPV **12** of FIG. **2**. For example, as depicted, the BPV **12** includes one embodiment of the body **42**, the friction member **44**, the outer sleeve **46**, the lock ring **48**, the plunger **50**, and the seal **52**.

In the illustrated embodiment, the body **42** includes a lower body portion **120** and an upper body portion **122**. The lower body portion **120** includes the plunger bore **64**. The plunger bore **64** includes a plunger bore sealing face **124**. In the illustrated embodiment, the plunger bore sealing face **124** includes a taper between a lower plunger bore portion **126** and an upper plunger bore portion **128**. The taper **124** includes an angled face (e.g., conical shaped face) that extends between the lower plunger bore portion **126** and the upper plunger bore portion **128**. The taper **124** is shaped complementary to a plunger sealing face **130**. In the illustrated embodiment, the upper plunger bore portion **128** is narrower (e.g., has a smaller diameter) than the lower plunger bore portion **126**.

The lower body portion **120** also includes a holding ring **132** coupled to the lower end **62** of the lower body portion **120**. The holding ring **132** is coupled to the lower body portion **120** via mechanical fasteners (e.g., bolts) **134**. The holding ring **132** extends into the lower plunger bore portion **126** and includes a stem bore **135** that extends through the center of the holding ring **132** along the longitudinal axis **54**. As is discussed in further detail below, the holding ring **132** retains the plunger **50** in the plunger bore **64**.

The plunger **50** includes a stem **136**, a bell **138**, and a spring **140**. The stem **136** is coupled to and extends downward form the bell **138**. In the illustrated embodiment, the stem **136** is aligned along the longitudinal axis **54** and extends into the stem bore **135** of the holding ring **132**. Further, the spring **140** is disposed around the stem **136** and is retained between the bell **138** and the holding ring **132**. Accordingly, as the plunger **50** is urged toward the holding ring **132** (e.g., where the plunger **50** is urged to an open position), the spring **140** provides a biasing force urging the plunger **50** to a closed position (e.g., the sealing face **130** of the bell **138** into contact with the plunger bore sealing face **124**.

In the illustrated embodiment, the bell **138** includes a seal **142** (e.g., annular seal) and a bell stem **144**. The seal **142** generally includes a seal configured to seal against the plunger bore sealing face **124**. The bell stem **144** includes a protrusion extended from the bell **138** in the direction of the upper plunger bore portion **128**. In operation, the bell stem **144** enables a tool or similar device to engage the plunger via the upper plunger bore portion **128**. For example, as is discussed in further detail below, in one embodiment, the running tool **112** is threaded into a thread **146** of the upper plunger bore **128** and depresses the plunger **50** via the bell stem **144**, thereby urging the plunger **50** toward an open position.

The upper body portion **122** includes a cylindrical ring that is coupled to the lower body portion **120**. In the illustrated embodiment, the upper body portion **122** includes a cylindrical ring that is disposed about an external diameter of an upper end **148** of the lower body portion **120**. The upper body portion **122** is coupled to the lower body portion **120** via a mechanical fastener (e.g., a bolt) **150**.

Further, the upper body portion **122** includes a hollow center **152**. As is discussed in further detail below, the hollow center **152** is capable of receiving at least a portion of the BPV running tool **112**. An upper body hydraulic port **154** extends from an interior surface of the hollow center **152** and extends through the upper body portion **122** to a lower end **156** of the upper body portion **122**. The upper body hydraulic port **154** terminates into a cavity **158** formed between the upper body portion **122**, the lower body portion **120** and the outer sleeve **46**. The cavity **158** is sealed via three annular seals **160**, **162** and **164** disposed between the upper body portion **122**, the lower body portion **120** and the outer sleeve **46**.

The friction member **44** includes, in the illustrated embodiment, segments disposed in the recess **66** of the lower body portion **120**. The friction member **44** is coupled to the body **42** via fasteners (e.g., bolts) **166**. The fasteners **166** are passed through through-holes **166**. The through-holes **166** includes slots that enable the friction member **44** to move relative to the fasteners **166** and the body **42**. More specifically, the friction member **44** is capable of being moved axially up and down in the recess to contract and expand, respectively, the friction member **44**. For example, in the illustrated embodiment, the friction member **44** is in the radially contracted (e.g., up) position, and may be slid/urged into the radially expanded (e.g., down) position, as discussed previously with regard to FIG. **2**.

The outer sleeve **46** includes a cylindrical body **170** disposed around the exterior of the body **42**. In the illustrated embodiment, the outer sleeve **46** extends both above and below the friction member **44**. For example, the body **170** of the outer sleeve **46** includes windows **172** that span the region proximate the friction member **44**. More specifically, the windows **172** include cutouts through the body **170** that enable the outer sleeve **46** to slide in a longitudinal direction (e.g., parallel to the longitudinal axis **52**) relative to the body

42 and/or the friction member 44. For example, the windows 172 include an upper window face 174 and a lower window face 176 that are separated by a distance that is greater than the height 88 of the friction member 44. Accordingly, in the illustrated embodiment, the outer sleeve 46 can be moved longitudinally downward for a distance before the upper face 174 of the body 170 contacts/engages the upper face 84 of the friction member 44. As is discussed below, this longitudinal movement can be employed to urge the seal 52 into a seated position. Further, the outer sleeve 46 can continue to move in the longitudinal downward direction to engage the upper face 84 of the friction member 44 and to cause the friction member to move downward in the recess 66 and expand radially, as discussed above with regard to FIG. 2.

In the illustrated embodiment, the seal 52 includes a MEC seal 52 disposed at a lower end 180 of the outer sleeve 46. As discussed previously, urging the outer sleeve 46 downward displaces the seal 52 downward along the longitudinal axis 54. As the seal 52 is urged downward, it is compressed between the tapered face 98 of the body 42 and the bore 40 until it is proximate and/or disposed in a seated position.

An upper end 182 of the outer sleeve 46 includes shear pin holes 184 that support shear pins 186 disposed between the outer sleeve 46 and the lock ring 48. Further, the upper end 182 includes a recess 188 that houses bearings 190 disposed between the outer sleeve 46 and the lock ring 48. Similarly, the lock ring 48 includes complementary shear pin holes 192 configured to support the shear pins 186 and a complementary bearing groove 194 that supports and houses the bearings 190.

The lock ring 48 includes a cylindrical ring that is disposed about the upper portion 122 of the body 42. In the illustrated embodiment, the lock ring 48 includes threads 196 about the internal diameter that are complementary to external threads 198 about the external diameter of the upper body portion 122. Accordingly, rotation of the lock ring 48 relative to the upper body portion 122 imparts a longitudinal movement of the lock ring 48 along the longitudinal axis 54. For example, rotating the lock ring 48 may secure the outer sleeve 46 in a locked position as discussed previously with regard to FIG. 2. Further, in the illustrated embodiment, the lock ring 48 includes axial slots 199. In operation, the slots 199 are engaged by complementary protrusions of the BPV running tool 112. The slots 199 transfer rotational torque from the BPV running tool 112 to the lock ring 48. Accordingly, rotation of the BPV running tool 112 imparts a rotation of the lock ring 48 via the slots 199, in one embodiment.

Turning now to the BPV running tool 112, as illustrated in FIG. 3, the BPV running tool 112 includes a lower tool portion 200 and an upper tool portion 202. The lower tool portion 200 includes a stem 204, a threaded portion 206, a hydraulic port 208, seals 210 and 212, a check valve 214, a groove 216, and slots 218. The upper body portion 202 includes a recess 220, internal protrusions 222, a port 224, a check valve stem 226, and external protrusions 228.

The stem 204 includes a protrusion along the longitudinal axis 54 and extending downward. In operation, the stem 204 engages the bell stem 144. In other words, as the BPV tool 112 is lowered into and/or engaged with the BPV 12, the stem 204 engages the bell stem 144, thereby urging the plunger 50 into the open position.

The threaded portion 206 includes an external thread that is complementary to the thread 146 of the upper plunger bore 128. Accordingly, rotation of the lower portion 200 of the BPV running tool 112 relative to the body 42 generates longitudinal movement of the lower portion of the BPV running tool 112 relative to the body 42 and the BPV 12. For example, prior to deploying the BPV 12 and the BPV running tool 112, the BPV running tool 112 is coupled to the BPV 12 via the threaded portion 206 and the thread 146 of the upper plunger bore 128. When threaded together, the longitudinal movement of the lower portion 200 of the BPV running tool 112 relative to the body 42 and the BPV 12 causes the stem 204 to urge the plunger 50 into an opened position.

The hydraulic port 208 includes a bore that extends from an upper end 230 of the lower portion 200 of the BPV running tool 112 and terminates in the external diameter of the lower body portion 200. In the illustrated embodiment, the hydraulic port 208 includes an L-shape that enables the port 208 to align with the hydraulic port 154 in the upper body portion 122 of the body 42 of the BPV 12. When the BPV 12 and the BPV running tool 112 are assembled, the two seals 210 and 212 flank the hydraulic ports 208 and 154 enabling pressurized fluid to pass between the ports 208 and 154. For example, as is discussed in further detail below, hydraulic fluid is injected into the cavity 158 via the hydraulic ports 154 and 208 to urge the outer sleeve 46 into a locked position.

Further, the check valve 214 is disposed in the hydraulic port 208. More specifically, the check valve 214 is disposed in the upper end 230 of the lower portion 200 of the BPV running tool 112. The check valve 214 helps to block hydraulic fluid from reversing in direction once injected into the hydraulic port 208. In other words, the check valve helps to maintain pressure within the hydraulic port 208. In operation, the check valve is opened via the check valve stem 226 that protrudes from the upper portion 202 of the BPV running tool 112. In the illustrated embodiment, the check valve stem 226 is disposed in the port 224 of the upper portion 202, and includes a port 232 that extends through its length. Accordingly, the check valve stem 226 engages the check valve 214 (e.g., depresses or moves the check valve 214 along the longitudinal axis 54, and enables hydraulic fluid to pass from the port 224 to the hydraulic port 208, in the illustrated embodiment.

The groove 216 of the lower portion 200 includes an annular recess in the circumference that is engaged by the internal protrusions 222 of the upper portion 202. The slots 218 include a plurality of depressions that extend upward from the groove 216 and are spaced around the circumference of the upper end 230 of the lower portion 200 of the BPV running tool 112. The slots 218 are sized such that the internal protrusions 222 engage the slots 218 when the upper portion 202 and the lower portion 200 are moved longitudinally relative to one another. For example, as is discussed in further detail below, the protrusions 222 include stems that extend inward into the groove 216 enabling the upper portion to rotate about the lower portion 200 in the illustrated position. Upward axial movement of the upper portion 202 causes the internal protrusions 222 to engage the slots 218, thereby enabling the rotational torque of the upper portion 202 to rotate the lower portion 200.

The external protrusions 228 include pins or similar extensions that protrude from the external diameter of the upper portion 202. As discussed previously, the external protrusions 228 are configured to engage the slots 199 of the locking ring 48. Accordingly, rotation of the upper portion 202 translates into rotation of the locking ring 48, in certain embodiments.

It is further noted that the upper portion 202 includes an attachment thread 234. The attachment thread 234 includes an internal thread that is couplable to casing, tubing, or a similar device employed to run the BPV **12** and/or the BPV running tool **112** into the bore **40**. For example, casing is threaded into the attachment thread **234** to support the BPV running tool **112** and to provide for the delivery of hydraulic fluid in one embodiment.

Turning now to FIG. **4**A-**4**C a sequence of installing the BPV **12** is illustrated. FIG. **4**A depicts the BPV **12** and the BPV running tool **112** assembled to one another and disposed in the straight bore **40**. In the illustrated embodiment, the check valve stem **226** has engaged the check valve **214**, the external protrusions **222** are located in the groove **216**, the hydraulic port **208** of the BPV running tool **112** is aligned with the hydraulic port **154** of the body **42** of the BPV **12**, the shear pins **186** are intact (e.g., un-sheared), the stem **204** of the BPV running tool **112** has engaged the bell stem **144** of the plunger **50** (e.g., urged/depressed the plunger **50** to the open position), the friction member **44** is disposed atop the recess **66** in the radially contracted position, a distance **240** exists between the upper face **84** of the friction member **44** and the upper window face **174**, and the seal **52** is engaged by the taper **98** of the body **42**. In other words, the BPV **12** is lowered into the bore **40** in a pre-landing position.

FIG. **4**B depicts the BPV system **10** after hydraulic loading of the BPV system **110**. In the illustrated embodiment, hydraulic fluid is injected into the cavity **158** via the hydraulic ports **208** and **154**. As hydraulic fluid is injected into the cavity **158**, the increase in pressure and volume causes a longitudinal downward force on the outer sleeve **42** in the direction of the arrows **92**. The resulting downward force and movement of the outer sleeve **46** shears the shear pins **186**, and urges the outer sleeve **46** downward in the direction of the arrows **92** into engagement with the friction member **44**. In other words, the downward movement of the outer sleeve **46** eliminates the distance between the upper face **84** of the friction member **44** and the upper window face **174** until the upper window face **174** engages the upper face **84** of the friction member **44**. The movement of the outer sleeve **42** creates a gap **160** between the lock ring **42** and the outer sleeve **46**.

In the illustrated embodiment, the outer sleeve **46** continues to urge the friction member **44** downward, creating a gap **242** between the body **42** and the friction member **44** and radially expanding the friction member in the direction of the arrows **90**. The radial expansion causes the friction face **80** of the friction member **44** to engage the internal diameter of the bore **40**. Further, the seal **52** is driven longitudinally beyond the taper **98** in the body **42** into a seated position. In other words, the seal is compressed between the body **42** of the BPV **12** and the bore **40**. With the cavity **158** pressurized and the outer sleeve **46** urged into the engage position, the BPV running tool **12** is moved up such that the check valve **214** is disengaged by the check valve stem **226**. Accordingly, FIG. **4**B depicts the BPV system **110** wherein the BPV **12** has been hydraulically pressurized, and the BPV running tool **112** is hydraulically disengaged from the BPV valve **12**.

FIG. **4**C depicts the lock ring **48** rotated into a locked position. For example, with the BPV **12** hydraulically pressurized, and the BPV running tool **112** hydraulically disengaged from the BPV valve **12**, the upper portion **202** of the BPV running tool **112** is rotated. Rotation of the upper portion **202** of the BPV running tool **112** is provided via rotation of the casing, tubing, or other device coupled to the attachment threads **234**, in one embodiment. Accordingly, rotational torque generated by rotating the upper portion **202** of the BPV running tool **112** is transferred to the slots **199** of the locking ring **48** via the external protrusions **228**. The resulting rotation of the lock ring **48** about the threads **196** and **198** causes the locking ring **48** to move longitudinally downward in the direction of the arrows **96**. The rotation is continued until the lock ring **48** is proximate or engages the outer sleeve **46**. In other words, the gap **160** is reduced and/or eliminated. Accordingly, the illustrated embodiment includes the lock ring **48** moved into a locked position. In the locked position, the lock ring **48** abuts the outer sleeve **46**, thereby securing the outer sleeve **46** and the friction member **44** in the radially expanded position.

FIG. **4**D depicts the upper portion **202** of the BPV running tool **112** moved upward such that the internal protrusions **222** are disengaged from the groove **216** and have engaged the slots **218** located above the groove **216**. In other words, once the lock ring **48** is disposed in the locked position, the upper portion **202** of the BPV running tool **112** is retracted upward such that the external protrusions **220** disengage the slots **199** of the lock ring **48** and the internal protrusions **222** engage the slots **218** of the lower portion **200** of the BPV running tool **112**. With the internal protrusions **222** engaged in the slots **218**, the upper portion of the BPV running tool **112** is rotated, for example, via rotation of the casing, tubing, or other device coupled to the attachment threads **234**, causing rotation of the lower portion **200** of the BPV running tool **112** that disengages the threaded portion **206** of the lower portion of the BPV running tool **112** to disengage threads **146** in the body **42** of the BPV **12**. Accordingly, rotation of the BPV running tool **112** longitudinally disengages the BPV running tool **112** from the BPV **12**. In one embodiment, once the BPV running tool **112** is disengaged from the BPV **12**, the BPV running tool **112** is retrieved/extracted (e.g., retrieved to a vessel in a subsea system **10**).

FIG. **4**E depicts an embodiment wherein the BPV **12** is installed in the straight bore **40** and the BPV running tool **112** is disengaged and retrieved from the bore **40**. More specifically, the friction member **44** is radially expanded into engagement with the internal surface of the bore **40**, the lock ring **48** is set in the locked position, the seal **52** is seated, and the BPV running tool **112** is retrieved from the bore **40**.

As discussed above with regard to FIG. **2**, the embodiments discussed with regard to FIGS. **3** and **4**A-**4**E may include any combination or variation of features. For example, the embodiments may include various configurations of the friction member **44** (e.g., a C-Ring, segments, and/or locking dogs). Further, the friction face **80** may include any variety or combination of surface finishes (e.g., scoring, grooves, teeth, etc.). In addition, the seal **52** may include a MEC seal and/or a LS seal. Further, although not depicted, retrieval of the tool may generally include the BPV running tool **112** being lowered to the BOV **12**, rotating the BPV running tool **112** to back-off the lock ring **48** and relieve the longitudinal force holding the outer sleeve **46** and the friction member **44** in place, and extraction of the BPV **12** and the BPV running tool **112** via the bore **40**.

While the invention may be susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and have been described in detail herein. However, it should be understood that the invention is not intended to be limited to the particular forms disclosed. Rather, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the following appended claims.

The invention claimed is:

1. A method, comprising: selectively moving a friction member between a first radial position and a second radial position relative to a body of a valve, wherein the friction member is configured to move from the first radial position to the second radial position in response to a first hydraulic force provided by a running tool to secure the valve in a straight portion of a bore only with friction, and the friction member is configured to move away from the second radial position toward the first radial position to release the valve from the straight portion of the bore.

2. The method of claim **1**, wherein selectively moving the friction member comprises hydraulically driving the friction member between the first and second radial positions via the first hydraulic force or a second hydraulic force provided by the running tool.

3. The method of claim **2**, wherein hydraulically driving the friction member comprises hydraulically moving a sleeve to bias the friction member between the first and second radial positions.

4. The method of claim **3**, wherein hydraulically moving the sleeve comprises axially moving the sleeve along a longitudinal axis.

5. The method of claim **3**, comprising locking the friction member in position after hydraulically moving the sleeve.

6. The method of claim **5**, wherein locking the friction member comprises blocking movement of the sleeve with a lock member driven in place by the running tool.

7. The method of claim **6**, wherein locking the friction member comprises hydraulically moving the lock member via the running tool, threadingly moving the lock member via the running tool, or a combination thereof.

8. The method of claim **1**, wherein selectively moving the friction member comprises driving the friction member between the first radial position at a first axial position and the second radial position at a second axial position, the first and second axial positions are offset from one another, and the first and second radial positions are offset from one another.

9. The method of claim **1**, wherein selectively moving the friction member comprises driving the friction member along a tapered interface between the friction member and the body of the valve.

10. The method of claim **1**, comprising locking the friction member in position after moving the friction member between the first radial position and the second radial position.

11. The method of claim **10**, wherein locking the friction member comprises blocking movement of the friction member with a lock member mechanically secured in place.

12. The method of claim **1**, comprising balancing pressure on opposite sides of the valve with a valve structure that selectively moves between a closed position and an open position.

13. The method of claim **1**, comprising securing the valve in the straight portion of the bore only with friction, wherein the bore is disposed in a Christmas tree, a wellhead, or a combination thereof.

14. The method of claim **1**, comprising operating the valve running tool configured to selectively apply the first hydraulic force to move the friction member between from the first radial position to the second radial position and to selectively apply a second hydraulic force to move the friction member from the second radial position to the first radial position.

15. A system, comprising: a friction member configured to move between a first radial position and a second radial position relative to a body of a valve, wherein the friction member is configured to move from the first radial position to the second radial position in response to a first hydraulic force provided by a running tool to secure the valve in a straight portion of a bore only with friction, and the friction member is configured to move away from the second radial position toward the first radial position to release the valve from the straight portion of the bore.

16. The system of claim **15**, wherein the friction member is configured to move away from the second radial position toward the first radial position in response to a second hydraulic force provided by the running tool to release the valve from the straight portion of the bore.

17. The system of claim **15**, comprising a sleeve configured to bias the friction member between the first and second radial positions.

18. The system of claim **15**, comprising a lock member configured to lock the friction member in position after moving the friction member between the first radial position and the second radial position.

19. The system of claim **15**, wherein the friction member is configured to move between the first radial position at a first axial position and the second radial position at a second axial position, the first and second axial positions are offset from one another, and the first and second radial positions are offset from one another.

20. The system of claim **15**, wherein the friction member is configured to move along a tapered interface between the friction member and the body of the valve.

21. The system of claim **15**, wherein the valve comprises a valve structure configured to selectively move between a closed position and an open position to selectively balance pressure on opposite sides of the valve.

22. The system of claim **15**, wherein the valve is disposed in the straight portion of the bore only with friction, wherein the bore is disposed in a Christmas tree, a wellhead, or a combination thereof.

23. The system of claim **15**, comprising the running tool, wherein the running tool is configured to selectively apply the first hydraulic force to move the friction member from the first radial position to the second radial position, and the running tool is configured to selectively apply a second force to move the friction member from the second radial position to the first radial position.

24. The system of claim **23**, wherein the valve running tool comprises:

a stem configured to engage a valve plunger of the valve;

a protrusion configured to engage a lock member of the valve, wherein the lock member is configured to block movement of the friction member; and

a first hydraulic port configured to provide a fluid path to a second hydraulic port of the valve.

25. The system of claim **15**, wherein the friction member comprises a smooth surface configured to engage the straight portion of the bore only with friction.

26. The system of claim **15**, wherein the friction member comprises a surface having a coating configured to engage the straight portion of the bore only with friction.

27. The system of claim **15**, wherein the friction member comprises a surface having a texture configured to engage the straight portion of the bore only with friction.

28. The system of claim **15**, wherein the friction member comprises a surface having teeth configured to engage the straight portion of the bore only with friction.

29. The system of claim **15**, wherein the friction member comprises a plurality of friction segments disposed circumferentially about an axis of the body of the valve.

30. A system, comprising: a valve running tool configured to selectively apply a force to move a friction member between a first radial position and a second radial position relative to a body of a valve, wherein the friction member is configured to move from the first radial position to the second radial position in response to a first hydraulic force provided by the valve running tool to secure the valve in a straight portion of a bore only with friction, and the friction member is configured to move away from the second radial position toward the first radial position to release the valve from the straight portion of the bore.

31. The system of claim **30**, wherein the valve running tool comprises:

a stem configured to engage a valve plunger of the valve;

a protrusion configured to engage a lock member of the valve, wherein the lock member is configured to block movement of the friction member; and

a first hydraulic port configured to provide a fluid path to a second hydraulic port of the valve.

* * * * *